Eye-position signals in primary visual cortex during fixation, saccades, and smooth-pursuit eye movements.

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Visual input would be of little use if not accompanied by knowledge of eye position; indeed, it is the combination of these signals that allows the brain to localise and interact with objects meaningfully. Eye-position signals have been observed throughout visual cortex – including the primary visual area (V1) – but little is known about how well such signals represent the eye during different types of oculomotor behavior. To examine the representation of eye-position in macaque V1, we recorded the extracellular activity of multiple neurons as the animal performed sequences of fixations, saccades, and smooth-pursuit eye movements. Throughout the task, the neurons were stimulated visually by a flickering noise stimulus. Consistent with previous reports, we found that many neurons showed systematic modulations of visually-evoked activity by the position of the eyes in the orbit (i.e. 'gain fields'). These modulations occurred similarly during fixation and smooth pursuit. To assess the dynamics, accuracy, and reliability of these eye position signals, the neural data from each trial were decoded (using maximum-likelihood) to provide moment-to-moment estimates of eye position. The results show that the representation of eye position is accurate during fixation and updated rapidly in response to eye movements (within 50-100ms). These findings suggest that V1 carries a robust representation of eye position and is therefore likely to provide a useable head-centric representation of visual space.